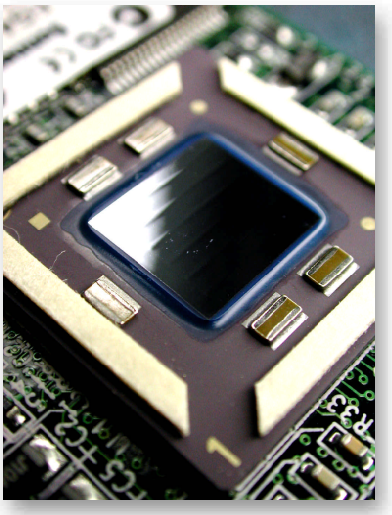
Section 4

SERVICES AND CAPABILITIES



Excellence in the selection, evaluation, and acquisition of reliable microelectronics for space applications based on the latest technical knowledge, superior laboratory capabilities, efficient and cost effective processes, and commitment to customer service.

EPE Vision Statement

SERVICES and CAPABILITIES

2002 Annual Report EPE

Overview

The JPL Electronic Parts Engineering organization provides a suite of parts assurance services to help satisfy JPL mission requirements.

The services include:

- Development and implementation of electronic parts programs
- Establishing parts requirements and plans in accordance with project needs
- Support to designers in part selection and evaluation
- Radiation tests, characterization and analysis services
- Part performance and environmental evaluations and test
- Reliability tests and failure analysis
- Procurement and acquisition of flight electronic parts
- Inventory and records control of flight electronic parts

The Electronic Parts Engineering organization operates a number of facilities in support of activities. These facilities include the Radiation Effects Laboratory, the Reliability & Failure Analysis Laboratory, the Flight Electronic Parts Store

PRODUCT EVALUATION

We characterize emerging part technologies that have not yet been qualified. The first step is to identify the most promising part types, acquire a sample of the parts and perform parameter characterization tests verifying performance per the data sheet over the manufacturer's specified temperature ranges. If this initial characterization is satisfactory, another sample of parts is procured to perform qualification tests.

These qualification tests include:

Reliability and Failure Analysis

Destructive physical analysis (DPA) assesses the materials and processes used to fabricate the device. In a typical DPA, the external markings are examined to ensure that the part is properly identified by type, manufacturer, date code, etc. Hermetically sealed packages are tested for possible leaks (hermeticity tests) and entrapped gases (residual gas analysis), and all sealed packages are tested for particle impact noise detection (PIND). The strength of the attachment of the die to the package and of the bonds to the bond pads is measured by die shear and bond pull strength tests. The materials used for the interconnect metallurgies and dielectric layers are determined by Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray (EDX) Analysis; the adequacy of step coverage is assessed by SEM.

Electrostatic discharge (ESD) testing assesses the susceptibility of devices to ESD events. Low-temperature characterization is done when there are projects that have applications whose temperature extremes are beyond the manufacturer's guaranteed limits.

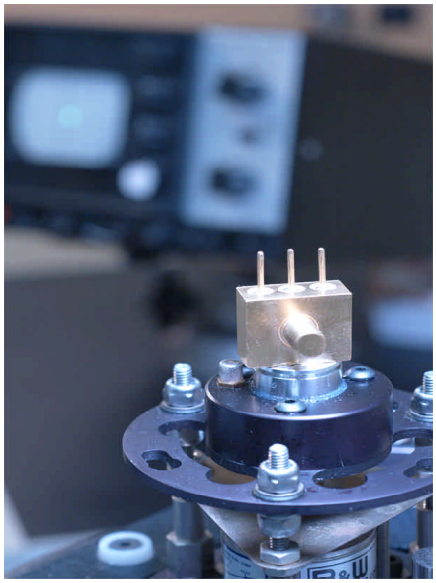
Low-voltage characterization ascertains whether parts that are designed for a common supply voltage (e.g., ?5 volts) can be used at a lower supply voltage (e.g., 3.3 volts) which could save power.

Optoelectronic testing tests high-energy protons and heavy ions. Special equipment is available to measure electrical and optical characteristics of optical emitters, optocouplers and transmitters, and optical fibers.

Temperature cycling is performed to ascertain

whether parts can meet either the MIL-STD of 100 cycles from -65° C to 150° C or some more stringent project specific requirement. If these tests are successful, the parts are then recommended for usage in flight projects.

In 2002, we installed new optical characterization systems. These include temperature dependent electroluminescence and photoluminescence spectroscopy, (from 10 K to 320 K). The system resolution is within 0.1 nm. Examples of measurement capabilities are device characteristics before and after accelerated life testing, and optical device performance at extreme (low) temperature. This type of measurement can be used in most optoelectronic devices, and on many RF III-V devices as well. (This work was done in collaboration with students from California State University, Northridge.)

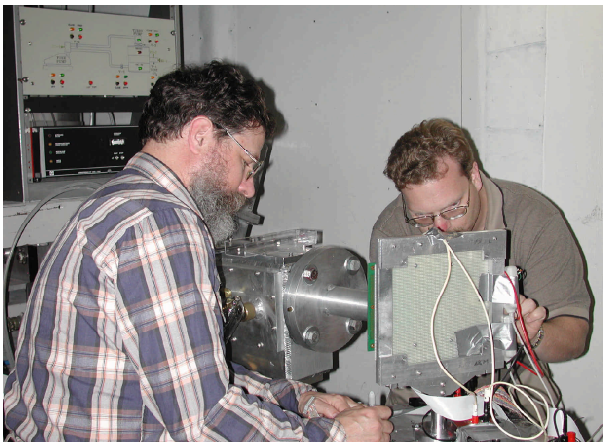


We also installed a self-contained, portable thermal vacuum chamber. This chamber has the capability of testing in vacuum conditions, and it can reach and maintain vacuum levels of 5 x 10^{-7} Torr (or better) at room temperature, and 1 x 10^{-6} Torr at high temperatures. Different gaseous atmospheres can be introduced into the chamber (up to pressures of 2 atmospheres), enabling various types of environmental testing. Available testing temperatures range from room temperature to 400° C with a stability of ±1° C. The chamber has a total of 150 electrical feed-throughs for in situ electrical monitoring. Some potential uses of this chamber include high-temperature accelerated life testing, environmental degradation studies, and electromigration in novel metallization systems.

Finally, Sigma Systems M30 computer controllable thermal chamber was installed to increase testing capabilities for both cycling and static temperature testing at extreme temperatures from -175° C to +250° C. With small thermal masses, the chamber has achieved a ramp rate of 10° C/min. Inert atmosphere testing can be achieved through a built-in gas purge, currently using nitrogen. Adjustable fail-safe over-temperature and under-temperature protection is built in to the system, and is active in both manual operation and remote operation. A secondary redundant, fail-safe apparatus has been installed for flight parts testing. The test chamber is 33 cm (l) x 25 (w) x 33 cm (h), and has eight 7.6-cm x 1.3-cm door feed-throughs and one 5-cm side port. The computer program consists of a three step configuration, warm-up cycle, test cycle, and cool-down cycle. Temperature, set point, and time stamping data are collected at the operator's set time interval. A real-time display monitors current set point and temperature with a second overall display of the temperature.

Radiation Testing

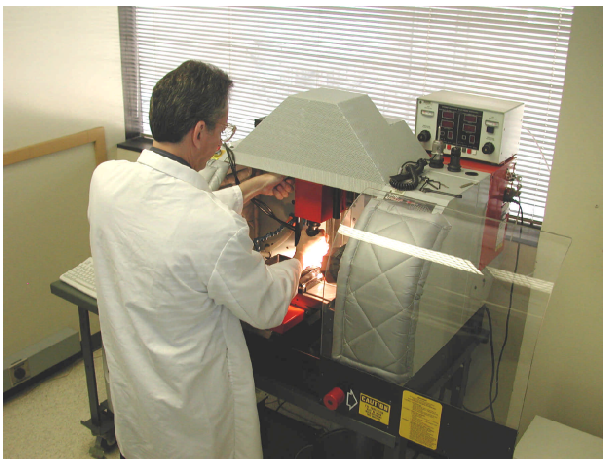
Single-event effects testing, including effects from protons and cosmic rays (heavy ions) requires off-



site tests at particle accelerators using special hardware that is compatible with accelerators (heavy ion tests must be done on delidded devices in a vacuum chamber). Special computer-controlled instrumentation is needed in order to do these evaluations in real time at off-site facilities.

Total dose testing including tests at high dose rates and very low dose rates can be performed at local cobalt-60 sources which are available for component and subsystem testing. A special dedicated facility is available for low dose rate testing, which takes many months to complete and is required for some types of components. Special test systems are available for testing of complex analog and digital circuits.

In 2002, we installed a new automatic test system, Eagle ETS-364 to increase our test measurement capabilities. This test system will be mainly used for characterization and reliability evaluation testing of mixed-signal (high-precision analog-to-digital / digital-to-analog converters, high-speed amplifiers) and RF devices (phase-locked loops, low-noise amplifiers, and wireless devices). This Eagle tester has a true parallel source and measure for every pin, and integrated software for multi-site test program development. The test system consists of 64 digital channels, 160+ analog channel capability, and 8 RF ports. Analog channels have smart pin V/I' s (voltage and current source), in other words, automatic wave generator (AWG) and digitizer per pin. Digital pins can be operated up to 20 MHz and RF ports have a 3.3-GHz frequency range. In addition, each digital pin has 64k vector depth to store errors during functional test of high-density memory devices.



PARTS PROGRAM MANAGEMENT

A range of management services is available to support the development and implementation of space systems. These services provide a completely autonomous parts program which works directly with the designers to identify parts needs, prepare and manage budgets to acquire, test, stock and kit parts and provide full technical support to the project.

Requirements Development

Services provide include:

- Assistance in preparing parts program requirements for JPL flight projects or contractors.
- Parts program requirements, including radiation requirements suitable to the mission.
- Parts program plans which describe the methodology used to assure meeting the reliability requirements. Project-specific approved parts lists (APL).

Proposal Assistance

Help is available in developing rough order of magnitude (ROM) costs for the electronic parts. We can help proposers understand the cost impact of the mission environment (radiation, temperature, etc.) on the parts.

PARTS SELECTION SUPPORT

The Electronic Parts Engineering Office is positioned to track device technology across projects to identify similar advanced technology needs and help pool resources for qualification.

The process of qualifying new device technologies requires, but is not limited to, the following kinds of

testing:

- Reliability (life) testing
- Radiation effects testing and characterization
- Mechanical stress/thermal cycling testing

Performance testing and characterization over temperature

Parts users groups (PUGs) meetings are held regularly to provide circuit and systems designers with information on newly available COTS devices and emerging device technologies and to solicit feedback from designers concerning parts applications and requirements.

Parts Specialists stay current by attending conferences and acquiring knowledge of new and advanced device technologies to anticipate customer needs.

DATA MANAGEMENT

Parts List Management

The Electronic Parts Engineering Office maintains parts lists for JPL flight hardware. Basic lists are supplied by the design agency and maintained in the Electronic Parts Information Network System (EPINS), the Section parts database.

The lists contain information about the part, the particular board or subassembly which uses the part and the desired quantity of spares, as well as a variety of administrative information. The parts are linked by the database to the appropriate procurement or stores and are "allocated" when identified so that the availability status is clearly displayed and understood.

The database is also used for the kitting function, and allows JPL to accurately identify the hardware containing specific parts on demand, as in the case of a Government- Industry Data Exchange Program alert.

Parts Logistics Support

Section 514 specifies, orders, inspects and verifies the conformance of flight parts for JPL flight hardware. The synergistic team consists of:

- Component specialists to write the specifications where necessary and review the results of tests

- Contract technical managers who are familiar with the industry and can resolve contractual and technical issues very quickly

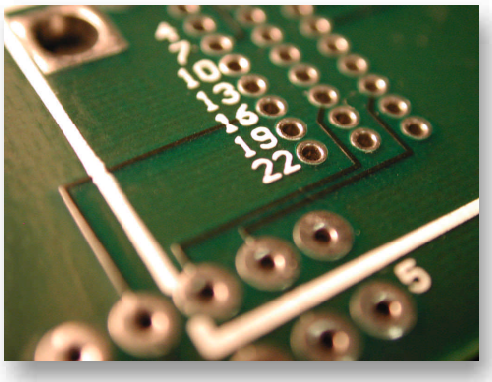
- Parts program managers who work the problems with the users to provide fast, effective and low-cost solutions to parts acquisitions and the associated problems.

RadData Web Database

The RadData server contains radiation effects test data for total ionizing dose (TID) and single event effects (SEE). This database is available for general use, both internally and externally, without written permission.

Section 5

PRODUCTS AND PUBLICATIONS



Excellence in the selection, evaluation, and acquisition of reliable microelectronics for space applications based on the latest technical knowledge, superior laboratory capabilities, efficient and cost effective processes, and commitment to customer service.

514 Vision Statement

2002 Annual Report EPE

Products and Publications

The products and publications listed in this section are based on results and studies of reliability and radiation effects experiments for JPL/NASA space flight applications. These various publications address discussions and recommendations of reliability and qualification of electronic parts for space environments. In addition, these papers provide comprehensive evaluation and characterization results, and guidance for flight projects to determine what steps to take, find out their needs, and develop a schedule and budget that will work for them.

1. M.P. Petkov, " A model for comprehensive studies of porosity in mesoporous low-k dielectrics," Mater. Res. Soc. Symp. Proc., 731, 285 (2002).

2. M.P. Petkov, K.G. Lynn, K.P. Rodbell, V. Wolksen, R.D. Miller, " Radiation effects in low dielectric constant methyl-silsesquioxane films," IEEE Trans. Nucl. Sci., 49, 2724 (2002).

3. " Preliminary reliability evaluation of commercially available low-k interlayer dielectrics for space applications," NEPP website

4. M.P. Petkov, K.G. Lynn, A. van Veen, " Experimental and theoretical aspects of electric-field-assisted positron kinetics in metal-oxide-silicon systems," Phys. Rev. B, 66, 045322 (2002).

5. M.P. Petkov, C.L. Wang, M. Weber, K.G. Lynn, K.P. Rodbell, " Positron annihilation techniques suited for porosity characterization of thin films," J. Phys. Chem. B (2002).

6. S. Marcinkevicius, J. Siegert, R. Leon, B. Echavius, B. Magness and W. Taylor, C. Lobo, " Changes in luminescence intensities and carrier dynamics induced by proton irradiation in InxGa1-xAs/GaAs quantum dots," Physical Review B 66, 235314 (2002).

7. R. Leon, S. Marcinkevicius, J. Siegert, B. Echavius, B. Magness and W. Taylor, C. Lobo, " Effects of Proton irradiation on Luminescence emission and carrier dynamics of self-assembled III-V quantum dots," IEEE Trans. Nucl. Sci. vol. 49, pp. 2844 (2002)

8. S. Marcinkevicius, J. Siegert, R. Leon, S. Chaparro, S.R. Johnson, C. Navarro, X. Jin, Y.H. Zhang, " Carrier dynamics in spatially ordered InAs quantum dots," Compound Semiconductors 2001, Institute of Physics Conference Series, (170): 543-548 2002

9. R. Leon, J. Ibanez, S. Marcinkevicius, J. Siegert, T. Paskova, B. Monemar, S. Chaparro, C. Navarro, S.R. Johnson, Y.H. Zhang, " Defect states in red-emitting InxAl1-xAs quantum dots," Physical Review B, 66 (8): art. no. 085331 Aug 15 2002

10. S. Marcinkevicius, R. Leon, B. Cechavicius, J. Siegert, C. Lobo, B. Magness, W. Taylor, " Changes in carrier dynamics induced by proton irradiation in quantum dots," Physica B, 314 (1-4): 203-206 MAR 2002

11. R. Leon, S. Chaparro, S.R. Johnson, C. Navarro, X. Jin, Y.H. Zhang, J. Siegert, S. Marcinkevicius, X.Z. Liao, J. Zou, " Dislocation-induced spatial ordering of InAs quantum dots: Effects on optical properties," Journal of Applied Physics 91 (9): 5826-5830 May 1 2002

12. K.P. Korona, A. Babinski, J. Kuhl, J.M. Baranowski, R. Leon, " Step-like photoluminescence dynamics in field-effect structures containing quantum dots," Physica Status Solidi B-Basic Research 227 (2): 605-612 Oct 2001

13. S. Marcinkevicius, A. Gaarder, R. Leon, " Rapid carrier relaxation by photon emission in In0.6Ga0.4As/GaAs quantum dots," PHYSICAL REVIEW B 64 (11): art. no. 115307 Sep 15 2001

14. J. Ibanez, R. Leon, D.T. Vu, S. Chaparro, S.R. Johnson, C. Navarro, Y.H. Zhang, " Tunneling carrier escape from InAs self-assembled quantum dots," Applied Physics Letters, 79 (13): 2013-2015 Sep 24 2001

15. R. Leon, J. Okuno, R. Ruiz, M. Gallegos, D.T.

Vu, " Reliability Issues in GaAs-Based Devices for Space Applications," presented at the Reliability Workshop of the 2001 IEEE GaAs IC Symposium, October 21 in Baltimore, MD

16. R. Leon, D. Vu, A. Johnson, R. Ruiz, J. Okuno, J. Uribe, G. Hather, J.R. Lloyd, " Electrical and Structural investigation of the effects of via-conductor geometry in the electromigration of Al:Cu," presented at the Fall Meeting of the Materials Research Society (2001)

17. R. Leon, J. Ibañez, J. Siegert, S. Marcinkevicius, T. Paskova, B. Monemar, S. Chaparro, C. Navarro, S. Johnson, Y.H. Zhang, " Interfacial States and Stark Shifts in Red Emitting InAlAs Quantum Dots: Discrimination of Defect Levels and QD Energy Levels," presented at the Spring meeting of the Materials Research Society, San Francisco, (2002)

18. J. Siegert, S. Marcinkevicius, A. Gaarder, R. Leon, S. Chaparro, S. R. Johnson, C. Navarro, X. Jin, Y. H. Zhang, " Dynamics of Photoexcited Carriers in InAs Quantum Dots Spatially Aligned by Misfit Dislocations," Spring Meeting of the Materials Research Society (MRS), San Francisco (2002).

19. S. Marcinkevicius, R. Leon, C. Lobo, B. Magness, W. Taylor, " Time resolved studies of proton irradiated quantum dots," presented at the Spring Meeting of the Materials Research Society (MRS), San Francisco (2002)

20. R. Leon, D. Vu, J. Colon, R. Ruiz, S. Johnson, J. Okuno, K. Evans, J. R. Lloyd, " Electromigration Issues in State-of-the Art and Emerging Metallization Systems," presented at the NEPP conference, April 31-May 2, Houston, TX

21. M. Gallegos, R. Leon, D. T. Vu, J. Okuno, S. Johnson, " Accelerated Life Testing and Temperature Dependence of Device Characteristics of GaAs CHFET Devices," presented at the International Integrated Reliability Workshop, Oct 21-24, 2002 in S. Lake Tahoe, CA

22. R. Leon, " Semiconductor Quantum Dots as radiation-hard light emitters," published in the Nov. 2002 issue of NASA Tech Briefs, Vol. 26, No 11.

23. R. Leon, " Inhibited carrier transfer in ensembles of quantum dots," published in the May 2002 issue of NASA Tech Briefs, Vol. 26, No 6

24. A. Johnston, "Proton Displacement Damage in Light-Emitting and Laser Diodes," IEEE TNS, Oct. 2001

25. JPL Test Report "Total Dose Characterization of the LM3940 Low Dropout Voltage Regulator" by J. Lehman et al. (internal document).

26. JPL Test Report "LMD18200 H-Bridge Total Dose Characterization" by J. Lehman et al. (internal document).

27. JPL Test Report "Total Dose Characterization of LT1074 Step Down Switching Regulator" by J. Lehman et al. (internal document).

28. JPL Test Report "Total Dose Characterization of the LT1813 Dual High Speed Op Amp" by J. Lehman et al. (internal document).

29. JPL Test Report "Total Dose Radiation Test Report Si9945 Dual N-Channel MOSFET" by J. Lehman et al. (internal document).

30. B. Pritchard et al., " Radiation Effects, Predicted, Observed, and Compared for Spacecraft Systems," *IEEE Radiation Effects Data Workshop, NSREC 2002,* pp. 7

31. T. Miyahira, A. Johnston, " Trends in Optocoupler Radiation Degradation," IEEE Trans. Nucl. Sci. vol. 49, pp. 2868 (2002)

32. A. Johnston, " Proton Damage in Optocouplers," presented at 2002 NEPP Workshop

33. D. Nguyen, L. Scheick, " SEE and TID of Emerging Non-Volatile Memories," *IEEE Radiation Effects Data Workshop, NSREC 2002,* pp. 62

34. F. Irom et al., "Single-Event Upset in the PowerPC7400 (G4) Microprocessor," presented at 2002 NSREC

35. S. McClure, L. Edmonds, R. Mihailovich, A. Johnston, P. Alonzo, J. DeNatale, J. Lehman, C.

Yui, "Radiation Effects in Microelectromechanical Systems (MEMS): RF Relays," IEEE Trans. Nucl. Sci. vol. 49, pp. 3197 (2002)

36. J. Patterson, L. Edmonds, "Modeling the Contribution of Diffusion to Device Upset Cross Section," IEEE Trans. Nucl. Sci., vol. 49, pp. 3067 (2002)

37. A. Johnston, " Single-Event Upset in PowerPC Processors," presented at 2002 RADECS Workshop
38. L. Scheick, G. Swift, "Dose Measurement Based on Threshold Shift in MOSFET Arrays in Commercial SRAMs," presented at 2002 RADECS Workshop

39. F. Irom, "Radiation Testing of PowerPC Processors," presented at 2002 SEE Symposium

40. L. Scheick et al., "Atypical SEE Phenomena in SDRAMs," presented at 2002 SEE Symposium

41. L. Scheick et al., "Dosimetry and Microdosimetry Using COTS ICs: A Comparative Study," presented at 2002 RADECS Workshop

42. L. Edmonds et al., "Ion-Induced Stuck Bits in 1T/1C SDRAM Cells," IEEE TNS, Dec. 2001

43. L. Edmonds, "A Method for Correcting Cosine-Law Errors in SEU Test Data," IEEE TNS, June 2002

44. L. Edmonds, "A Time-Dependent Charge-Collection Efficiency for Diffusion," IEEE TNS, Oct. 2001

45. H. Becker, "Latent Damage from Single-Event Latchup," presented at 2002 SEE Symposium

46. H. Becker, A. Johnston, "Latent Damage in CMOS Devices from Single-Event Latchup," IEEE Trans. Nucl. Sci. vol. 49, pp. 3009 (2002)

47. J. Lehman et al., "Low Dose Failure of Hardened DC-DC Power Converters," *IEEE Radiation Effects Data Workshop, NSREC 2002,* pp. 109

48. C. Yui et al., "Total Dose Dependency and ELDRS Effects on Bipolar Linear Devices," *IEEE Radiation Effects Data Workshop, NSREC 2002,* pp. 131

49. A. Johnston, "Enhanced Damage at Low Dose Rates in Linear Integrated Circuits," presented at NEPP '02 Workshop

50. Low Dose Rate Test Guideline (delayed to allow consideration of proposed changes in MIL-STD-883 Test Method 1019; to be completed in 1Q03)

51. S. Guertin, "Experimental Methods and Models for Single Event Transients in Linear Integrated Circuits," presented at 2002 SEE Symposium

52. A. Johnston, T. Miyahira, L. Edmonds, F. Irom "Single-Event Transients in High-Speed Comparators," IEEE Trans. Nucl. Sci. vol. 49, pp. 3082 (2002)

53. G. Swift, "Backside Device Thinning for Single Event Upset Rate Tests of Advanced Devices," 2002 SEE Symposium

54. J. Patterson, "Radiation Effects in MEMS Devices," presented at NEPP '02 Workshop

55. J. Patterson, "Radiation Tests of High-Density Memories," presented at NEPP '02 Workshop

56. L. Selva, "Experimental Techniques for SEE Tests at Low Temperatures," presented at 2002 SEE Symposium

57. L. Selva, L. Scheick, "Cold Temperature SEE Experiments on Advanced CMOS," presented at 2002 IEEE NSREC

58. A.Y. Kang, P.M. Lenahan & J.F. Conley, Jr., "The Radiation Response of the High Dielectric Constant Hafnium Oxide/Silicon System," IEEE Trans. Nucl. Sci. vol. 49, pp. 2636 (2002) (funded by JPL subcontract)

59. A. Johnston, "Mitigation Methods for Soft Errors and Related Radiation Effects in Spacecraft," special short course at 2002 International Reliability Physics Symposium (IRPS)

60. A. Johnston, "Single-Event Effects in Advanced CMOS Devices," invited talk at 2002 RADECS Workshop

61. JPL Test Report, "1000-V MOSFET Heavy Ion Test Report," S. S. McClure et al. (internal document).

62. JPL Test Report, "LM139 TID Test Report," S. S. McClure (internal document).

63. JPL Test Report, "LM185-1.2 TID/RLAT Test Report," S. S. McClure (internal document).

64. JPL Test Report, "LTC1019 Characterization Report," S. S. McClure (internal document).

65. JPL Test Report, LTC1019 TID/RLAT Report," S. S. McClure (internal document).

66. JPL Test Report,"Interpoint AMTR2805/15 TID Test Report," S. S. McClure (internal document).

67. JPL Test Report, "LT1963 Low Dropout Voltage Regulator Total Dose Characterization Procedure," S. S. McClure (internal document).

68. JPL Test Report, "LM124 TID Test Report," J. Lehman et al. (internal document).

69. JPL Test Report, "Lambda Advanced Analog DC/DC Converter Test Report," C. Yui (internal document).

70. JPL Test Report, "IRFMG40 N-Channel MOSFET Total Dose Radiation Test Report," B. Pritchard (internal document).

71. JPL Test Report, "Proton Damage Radiation Test Report for JANTX1N5665A Zener Diode," B. Pritchard (internal document).

72. S. Kayali, A. Johnston, " Reliability and Radiation Hardness of Compound Semiconductors," presented at 2002 International Journal of High-Speed Electronic Systems

73. S. Kayali, " Trends and Methods for Insertion of Advanced Microelectronics in Space Applications," presented at 2002 NASDA 15th Microelectronic Workshop

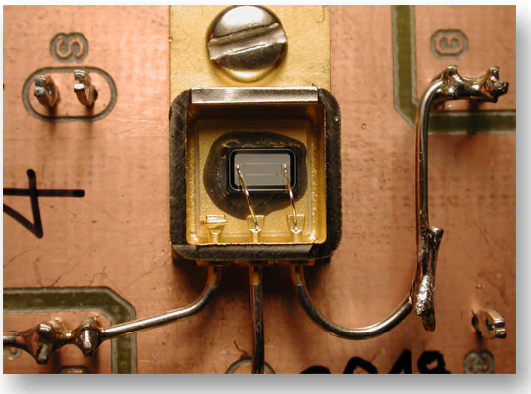
74. S. Kayali, " Utilization of Advanced Microelectronics in Space Applications," presented at 2002 Non Volatile Memory Symposium

75. S. Kayali, " Reliability and Qualification of Advanced Microelectronics for Space Applications," presented at 2002 CANEUS Conference

76. S. Kayali, " Utilization of COTS Electronics in Space Application, Reliability Challenges and Reality," presented at 2002 COTS Conference

Section 6

PARTNERSHIPS



Excellence in the selection, evaluation, and acquisition of reliable microelectronics for space applications based on the latest technical knowledge, superior laboratory capabilities, efficient and cost effective processes, and commitment to customer service.

514 Vision Statement

Professional and Academic

The Office encourages its staff to collaborate with other government laboratories, non-profit research institutions, universities, and industry.

THE AEROSPACE CORPORATION

The Office conducted the 2002 IEEE Microelectronics Reliability and Qualification Workshop (MRQW) in collaboration with The Aerospace Corp. This was the 5th Workshop, which provided a forum for open discussion in all areas of microelectronics reliability and qualification for high-reliability and commercial applications. Expert invited speakers presented latest results or work in progress in all areas of microelectronics device reliability and qualification methodologies, including Advanced space microprocessors, Advanced memories, FPGAs reliability and qualification, Advanced technologies reliability, Qualification methods, Designing in reliability using commercial processes, Space radiation effects, COTS/PEMS screening and qualification, DC/DC converter reliability, MEMS reliability.

CRANE interpoint

Partnership between the JPL Electronic Parts Engineering Office and Interpoint/Crane on the evaluation and test of DC/DC Converters has resulted in a number of findings and improvements in the application and manufacturing of products intended for space applications. Results of Destructive Physical Analysis (DPA) conducted by the JPL Reliability and Failure Analysis Group along with low and high dose rate radiation studies conducted by the JPL Radiation Effects Group resulted in design changes and improvements to manufacturing processes and in more reliable products. In addition, collaboration with Interpoint/Crane has allowed a more insightful assessment of these converter designs and improvements for future implementations.

Honeywell

Honeywell Space Systems manufactures high-reliability flight board systems using PowerPC microprocessors for military and high-reliability applications. These microprocessors need radiation characterizations, particularly for Single-Event Upsets (SEU), to support the aerospace applications. Collaboration has been started between the Radiation Group and Honeywell Space Systems to study SEU in advanced Silicon-On Insulator (SOI) commercial PowerPC microprocessors. In 2002, SEU measurements were done on the newest SOI PowerPCs manufactured by IBM and Motorola. Based on these test results, a paper was published (F. Irom et al., " Single-Event Upset in Commercial Silicon-on-Insulator PowerPC Microprocessors," IEEE Trans. Nucl. Sci. 49(6), pp. 3148-3155).

Maxwell TECHNOLOGIES

Maxwell Technologies has initiated a new partnership with the Radiation Effects Group to enable technology transfer to them of single-event effects (SEE) test expertise, particularly targeted at commercial processors and memories, particularly DRAMs. The collaboration not only relies on JPL's SEE test experience and expertise, but also uses unique JPL facilities, like Rad Group's Cf-252 irradiator and custom SDRAM testbed. This partnership is of obvious benefit to both parties; JPL expects that products purchased from Maxwell in the future will be accompanied by improved radiation test data, obviating the necessity of re-testing.

The Electronic Parts Engineering Office developed a collaboration agreement with Dr. John Suehle, Semiconductor Division, National Institute of Standards and Technology, on evaluating the radiation impact on advanced gate dielectric reliability in space applications. The current research effort includes evaluation of total ionizing dose and heavy ion effects on ultra-thin (24 A) silicon dioxide gate dielectric. In addition, the current focus of the collaboration is to investigate the total ionizing dose effects on advanced high-k gate material for 65-nm or below CMOS technologies.

The Radiation Effects Group is in its third year of collaborative single-event effects (SEE) testbed development with TIMA Laboratory of Grenoble, France. The THESIC+ testbed developed has proven very useful for both in-beam upset testing and benchtop fault injection experiments of PowerPC-family commercial processors that offer significant MIPS per watt computing advantages to JPL avionics system designers. Currently, the effort is shifting to concentrate on another type of attractive, but complicated commercial device, the field-programmable gate array, and to adapting the testbed to an in-space flight SEE experiment.

In a continuing multi-year project, the Radiation Effects Group has been developing single-event effects test capabilities which target a very attractive (to spacecraft designers) part type - the reconfigurable field programmable gate array (FPGA) - in co-operation with Xilinx, Inc. Xilinx manufactures a line of such FPGAs and is committed to providing the high-reliablity and aerospace market with products leveraged off their cutting-edge commercial products. The current focus of the collaboration is to develop and prove upset mitigation techniques which would enhance reliability so that, potentially, the critical applications could use reconfigurable FPGAs. Recently, as an indication of the success of the combined efforts, the partners have widened the joint-development into a consortium that presently includes active participation by Sandia Laboratory, The Aerospace Corp. and SEAKR Engineering, all of which are interested in using FPGAs in space.

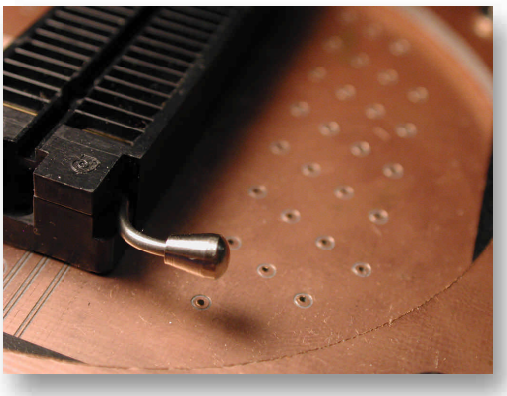
The Radiation Effects Group collaborated with the Department of Physics and Astronomy at Clemson University on the topic of flash memory reliability in extreme environments. With the demands on flash memory in space applications, like solid state recorders, increasing each year, the understanding and mitigation of deleterious phenomena like anomalous charge loss in cells, " flaky" bits, read and program disturb events, and radiation enhanced endurance reduction are key to mission success. Dr. Peter McNulty' s research with the Radiation Effects Group on charge migration mechanisms in the oxides of the floating gate cells has greatly increased understanding of failure mechanisms of flash memory. The environmental vectors of temperature, electrical stress, and radiation have all been studied.

The Office participated in a grant that supported undergraduate research at JPL. Undergraduate science and engineering interns collaborated with JPL scientists and engineers on various research topics. These topics included catastrophic radiation-induced effects in microelectronics, radiation and reliability response of electronics at cryogenic temperatures, analysis and characters of Microelectromechanical machines (MEMS), high-voltage power device reliability, as well as others. These students contributed significantly to research at the Office and are included on the byline of several research papers. In March 2002, the students presented their research at the Nation Conference of Undergraduate Research.

The Parts Engineering Group has been collaborating with Dr. Joseph Bernstein, the Reliability Engineering Center, University of Maryland at College Park to develop derating methodology and models for CMOS devices and technologies. The first phase of this work involves reliability testing design, analysis and statistical simulation of SRAM structures.

Section 7

STAFF BIOGRAPHIES



Excellence in the selection, evaluation, and acquisition of reliable microelectronics for space applications based on the latest technical knowledge, superior laboratory capabilities, efficient and cost effective processes, and commitment to customer service.

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Staff Biographies

Shri Agarwal holds M.S. degrees from the University of Southern California, Los Angeles; Indian Institute of Technology, Delhi, India; and Agra University, Agra, India. He has over 30 years' experience in the design, development and product engineering of microcircuit devices; and electronic parts engineering. He has supported JPL flight projects for over 20 years as a member of the Parts Engineering Group. His areas of specialty include digital, linear, interface and mixed-signal microcircuits; and hybrid crystal oscillators. He has been instrumental in developing several commercial products for use in space application. Over the years, he has had various ad hoc assignments including membership on JPL tiger teams. Currently, he is supporting COTS (Commercial Off The Shelf) evaluation efforts for NASA. He has made several presentations at technical meetings. He has received numerous honors including the individual and group achievement awards; NOVA awards; and a NASA medal.

Heidi Becker received her B.S. in physics from California State Polytechnic University, Pomona in 2001, and is currently involved in graduate work in optical sciences through the University of Arizona's Optical Sciences Center. She also holds a bachelor of fine arts degree from New York University. She joined the Jet Propulsion Laboratory in 2001 and is an associate engineer for the Radiation Effects Group of the Electronic Parts Engineering Office. Research and project work at JPL has included investigation into latent damage effects in microelectronics caused by single-event latchup, and radiation effects on multiple types of optoelectronic devices. Her work involving latent damage effects was presented at the 2002 Single Event Effects Symposium and the 2002 Nuclear and Space Radiation Effects Conference and was published in the December 2002 IEEE Transactions on Nuclear Science.

Thomas Brown has over 30 years' experience in aerospace and military engineering, including project management, contract management, technical sales, and new busineess development with background in electronic process engineering, manufacturing engineering, hybrid circuit design and fabrication, quality control and laboratory failure analysis techniques. He holds a B.S. degree in electrical engineering at Cleveland State University and some 70+ units of additional coursework in project management, business management, accounting, marketing, sales, international business, graphic communications and process control. He has been a parts project engineer at JPL since April 2001, responsible for managing a project' s parts engineering and procurement and providing technical, cost and schedule tracking throughout the design and development process. Specific JPL project experience includes LTMPF, LCAPE, MARSIS, MLS and OVWM.

Yuan Chen received a Ph.D. in reliability engineering from the University of Maryland at College Park. She also holds an M.S. in system engineering and B.S. in electrical engineering. She joined JPL in 2002 and is a senior engineer in the Parts Engineering Group, Office of Electronic Parts Engineering. Before coming to JPL she worked as a member of technical staff at VLSI Technology Reliability Group, Lucent Technology, in Orlando, Florida.

Mark Cooper has a B.S. in electrical engineering from City University of New York, an M.S. in electrical engineering from MIT, and a Ph.D. in physics from the University of California, Berkeley. He was S/V program manager at The Aerospace Corporation, and nuclear survivability and vulnerability engineer at GTE Sylvania on the AN/TTC-39 Program. In that assignment he performed radiation testing on numerous integrated circuits and some transistors and diodes. He worked for 25 years at Litton, initially performing a component radiation test program for the various cruise missile projects, then performed reliability analysis for advanced programs. Later he was the components engineering manager working on numerous projects, including Ring Laser Gyro, Zero Locked Gyro and Fiber Optic Gyro projects for a multitude of platforms including missile, avionics and space applications. He worked on early utilization of plastic encapsulated microelectronics in military avionics and missile applications, including selection guidelines and reliability assessments. Currently, he supports several

space projects at the Jet Propulsion Laboratory. He has published several articles in Physical Review and Journal of Applied Physics on research in many particle physics, and directed development of solid state surge arrestors. He has also published research on radiation effects in IEEE journals.

Saverio D' Agostino received his B.S. in metallurgical engineering in 1970 from the University of Illinois at Urbana-Champaign. He is a registered professional engineer in corrosion engineering. He originally worked at the Jet Propulsion Laboratory from 1979 to 1983 and returned in 1993. He is a principal engineer in the Failure Analysis Group of the Electronic Parts Engineering Office. He was the materials engineer on the Wide-Field Planetary Camera instrument and Galileo spacecraft. He holds several patents in High-G electronic packaging design and was the system packaging engineer for the Deep Space 2 Mars Microprobe Project. After the loss of the Mars Polar Lander, he was chief engineer for the development of a spacecraft flight data recorder (a.k.a "black box"). Recent work includes studies on the mechanisms of formation of tin whiskers and assessment of risk-of-formation of whiskers on electronic components with pure tin plating and as chief engineer for the DS2 Follow-on Experiment.

Larry Edmonds is a member of the Radiation Effects and Testing Group at the Jet Propulsion Laboratory. Responsibilities include the computation of single-event error rates in space, computer modeling of single-event effects, and laboratory charge collection measurements. His main interests are in mathematical physics with emphasis on analytical models of single-event effects. He has frequently served as a reviewer for the IEEE Transactions on Nuclear Science, and the Journal of Applied Physics. He and other group members received the JPL/NASA Excellence Award in 1998. He is the author or co-author of 26 papers in refereed journals. He holds a B.S. degree in math and physics from Union College and an M.A. in physics from State University of New York at Stony Brook.

Ed Erginsoy received his B.S. in engineering physics and mathematics in 1968, pursued his B.S. in electrical engineering in San Diego, and received his reliability technology Engineering certificate in 1975. He joined the Jet Propulsion Laboratory in 1998 as senior engineer in the Electronic Parts Engineering Office. He has published more than 12 papers, including work on SUPERFET mosfets, SUPERCAP ceramic multilayer multichip capacitors currently being used on the International Space Station. Other papers have covered Advanced Very High Resolution Radiometer (AVHRR) and Sounder scan systems, indium-gallium-arsenide, mercury-cadmium-telluride, indium antimonide and silicon photodiode detectors used on various spacecraft. He has a broad range of experience in detector materials, manufacturing and testing in electrical and electro-optical systems as well as EEE parts manufacturing, test and qualification processes. Ed and other members of his group received Outstanding Achievement Awards from Goddard SFC, the Space Station Program, NASA Glenn Research Center, and Johnson SFC for technical contributions. Since June 1998 Ed has been involved with various science missions for JPL.

Don Franzen graduated from McNeese State University with a B.S. in electronics engineering and an A.S. in instrumentation. He is currently enrolled in the Pepperdine MBA program. He joined JPL in 1998 and is a parts interface engineer in the Project Support Group of the Electronic Parts Engineering Office. He has worked as PIE for Mars Odyssey , Genesis, MUSES, Mars Express, and Mars Exploration Rover and is currently working on LAMP and Herschel/Planck.

Steve Guertin received his B.S. in mathematics and physics from California State Polytechnic University, Pomona, in 1998 and M.S. in physics from University of California, Los Angeles, in 2002. He is presently working on a Ph.D. in physics at UCLA. He joined the Jet Propulsion Laboratory in 1998 and is an associate member of the Radiation Effects Group of the Electronic Parts Engineering Office. He has published several refereed papers, including work on DRAM/SDRAM upset modes and processor radiation effects. His technical interests include large-scale data analysis techniques and test automation. Steve and other group members received the Outstanding Paper Award at the 1999 Nuclear and Space Radiation Effects Conference for their paper entitled "Angular and Energy Dependence of Proton Upset in Optocouplers," which explained how direct ionization from protons increases the upset rate in optocouplers.

Paul Hesse graduated from California Polytechnic University with a bachelor' s degree on electrical and electronics engineering. He continued education at the University of California, San Diego, with studies in

biomedical engineering and studied business management at the University of Southern California. He joined JPL in 1993, bringing an extensive background in satellite and space electronics having worked at Hughes, Northrop, McDonnell Douglas, Rockwell and Boeing, working with corporate research and science centers researching parts reliability and radiation effects; receiving awards for innovation, excellence and distinguished service on corporate boards and executive advisory councils. Since joining section 514, He has held the position of senior parts interface engineer for the SIRTF, TES, Deep Impact and Dawn Projects.

Farokh Irom received his B.S. in physics from the University of Tehran and his Ph.D. in particle physics from the University of California, Los Angeles, in 1981. He joined the Jet Propulsion Laboratory in 2000 and is a senior member of the Radiation Effects Group of the Electronic Parts Engineering Office. He has published more than 30 refereed papers, for which he was principle author of 7, in the physics journals. His work includes radiation effects in emerging microelectronics. He has a particular interest in silicon-on-insulator processes.

Allan Johnston received his B.S. and M.S. in physics from the University of Washington in 1963 and 1983, respectively. He worked for Ampex Corporation to develop semiconductor thin films for recording applications from 1963 to 1965. He joined Boeing Aerospace Corporation in 1965, working on radiation testing of microelectronics and optoelectronics for military and space applications. He managed a major laboratory in the Boeing High Technology Center from 1985 to 1992, directing work on radiation effects, highly reliable device development, and advanced microelectronics. He joined the Jet Propulsion Laboratory in 1992 and is currently the supervisor for the Radiation Effects Group, directing project support and applied research on radiation effects in advanced integrated circuits and photonics. He has published more than 80 refereed papers, including work on optocoupler degradation from space radiation, total dose degradation in linear integrated circuits at low dose rate, how device scaling impacts radiation effects in advanced CMOS devices, and proton degradation of light-emitting diodes, laser diodes, and optical detectors. Allan and other group members received the JPL/NASA Excellence Award in 1998. They also received the Outstanding Paper Award at the 1999 Nuclear and Space Radiation Effects Conference for their paper entitled "Angular and Energy Dependence of Proton Upset in Optocouplers," which explained how direct ionization from protons increases the upset rate in optocouplers. This was the mechanism behind shutdown in a power system on the Hubble Space Telescope, which occurred when the telescope passed through the south Atlantic anomaly in the earth's proton radiation belt. He has served in several positions for the IEEE Nuclear and Space Radiation Effects Conference, including technical chairman, awards chairman, short course chairman, and is the general chairman for the 2003 conference. He gave invited papers on scaling effects in advanced devices at the 1997 and 2002 RADECS Conference, as well as sections of the short course at the 1981, 1995 and 2000 Nuclear and Space Radiation Effects Conference, along with a short course at the International Reliability Physics Symposium in 2002. He is a fellow of the IEEE.

Sammy Kayali is manager of the Electronic Parts Engineering Office at the Jet Propulsion Laboratory in Pasadena, California. As such, he is responsible for the selection, evaluation and test of electronic parts utilized in high-reliability space applications. He is also responsible for managing the reliability and radiation effects research activities on electronic components and materials for space applications. His specialty is in the area of compound semiconductor device reliability, where he has over 30 publications, two patents pending, and a published book on the subject of GaAs MMIC Reliability. He has served as the chair of the International Reliability Physics Symposium's (IRPS) Compound Semiconductor Session, is a member of the GaAs Reliability Workshop Technical Program Committee, and has participated and chaired a number of various other industry working groups and workshops. He is the recipient of a number of honors and awards including the NASA Exceptional Service Medal. He holds degrees from Texas A&M University and Sam Houston State University in solid-state physics and electrical engineering.

Richard Kemski is the deputy manager of the Office of Electronic Parts Engineering. He received his B.S. in electrical engineering from the University of Massachusetts, Amherst in 1978. Richard started his career as a logic designer at Hughes Aircraft (now Boeing) for flight telemetry and command subsystems and attitude control subsystem test equipment. His design experience included custom ASIC design and microprocessor-based digital system designs for commercial applications. Richard has participated in several JPL missions over the past 15 years. He performed the worst-case analyses of the Magellan Synthetic Aperture Radar (SAR) Subsystem, Mars Observer Camera and the TOPEX Solar Array Drive Electronics. He also served on the memory "read disturb" tiger team on the Galileo memories. He joined JPL in 1990 as the parts program manager for the Cassini Project. After Cassini, he initiated the NASA Electronic

Parts and Packaging Program (NEPP), providing research on reliability, failure mechanisms and radiation effects on advanced microelectronics and MEMS, at JPL, for which he received the NASA Exceptional Service Medal. Richard has also served as mission assurance manager for X2000 (Advanced Avionics Development), ST4/Champollion and the Outer Planets/Solar Probe Projects.

Charlie Kyriacou is group supervisor of the Project Support Group. He graduated from the University of California, Los Angeles, with a B.S. in electrical engineering and an M.S. in communications systems. He worked at Hughes Aircraft for 10 years as a radar system engineer. He has been at JPL since 1987. Before moving into his current position, he worked as radar system test engineer for the Magellan project, proposal manager for EOS and ARISTOTELES, task manager for the Cassini Transponder (DST) and Advanced Transponder Development projects, and as technical group leader for the Spacecraft Transponder Group.

Choon Lee received a B.S. in electrical engineering (BSEE) from the University of California, San Diego, in 1984 and did his graduate work (MSEE) at the University of Southern California. He worked on radiation effects and hardness assurance programs at Litton Industry and GenCorp Aerojet for 7 years. Then, he joined the JPL in 1991 as a senior radiation effects engineer and published more than 13 radiation effects and qualification papers on various advanced COTS devices, such as high-resolution (14-/16-bit) ADCs and ultralow-power linear devices. He was responsible for planning, scheduling, testing, and report of electronic parts for radiation qualification and hardness assurance of flight projects until 1998. Recently, he managed the X2000 Parts Program and NEPP Electronic Parts Project to lead technical teams for advanced technology research and reliability evaluation.

Rosa Leon earned her B.A. in physics from Texas A&M University, her M.S. in physics from New Mexico State University, and her Ph.D. in materials science from the University of California, Berkeley. Previous employers include NASA Glenn Research Center (photovoltaic branch), the Center for Quantized Electronic Structures at the University of California, Santa Barbara, and the Department of Electronic Materials Engineering at the Australian National University. Rosa joined the Jet Propulsion Laboratory in 1998 and is now a principal research engineer in the Reliability and Failure Analysis Group. Some of Rosa's areas of experience comprise growth and characterization of epitaxial semiconductor structures for photovoltaic applications and for research in quantum structures, materials characterization (optical, structural, electrical and ion beam), and degradation mechanisms in devices for space applications. Rosa has also designed experimental techniques to measure minority carrier diffusion lengths to assess radiation damage in solar cells. Other topics of interest are in III-V semiconductors and devices, including low-dimensional quantum structures, electromigration in metallization systems, space qualification issues for various devices, including cryogenic applications, accelerated life testing, and biologically compatible semiconductor nanocrystals (based on II-VI compounds). Dr. Leon has organized several sessions and symposiums for various international conferences, she is an Executive Committee member for the American Conference on Crystal Growth - West (00 to 06), is a frequent referee for journals from the American Institute of Physics and the American Physical Society, and has received several honors and awards from her work. She has authored/co-authored over 80-refereed scientific publications, which have received over 800 citations and that include articles in Science, Nature, Physical Review Letters, Physical Review B and Applied Physics Letters.

Steve McClure received his B.S. in engineering physics from the California Polytechnic State University, San Luis Obispo, and did his graduate work in nuclear physics at the Department of Applied Science, University of California, Davis/Lawrence Livermore National Laboratory. He joined the Jet Propulsion Laboratory in 2000 and is a senior member of the Radiation Effects Group of the Electronic Parts Engineering Office. Prior to joining JPL he performed radiation effects analysis at the device and system level for a variety of programs having natural space and/or nuclear weapon radiation environments. He has authored several papers on total dose effects in semiconductor devices and holds a patent for a radiation hardening technique for CMOS microcircuits.

Robert Menke received his B.A. in electrical engineering (optics specialization) from the University of California, San Diego, in 1984 and received his M.S. in electrical engineering (solid state) from the University of Southern California. After working for over 6 years at Hughes Aircraft Co. as a component engineer specializing in active devices, he joined the Jet Propulsion Laboratory in 1991 to work as a parts manager for instruments on the Cassini Project. He went on to work numerous other

projects including AIRS, IAE, CSE, and Mars Pathfinder. In 1995 he moved to Denver, CO to work with JPL's industrial partner Lockheed Martin on the Mars '98 Project, where he was promoted to mission assurance manager (MAM) in 1996. After returning to California in 1997, he continued to work as a MAM and went on the 2001 Mars Odyssey Project, including working for almost a year in operations. In January 2002 he returned to the Electronic Parts Engineering Office as the supervisor of the Parts Engineering Group. He has received numerous achievement awards for his work including a NOVA award in 1996 for "innovation and improvement" on the Mars Pathfinder Project.

Tets Miyahira received his M.S. in computer science from West Coast University in 1977. He joined the Jet Propulsion Laboratory in 1987 and is a member of the Radiation Effects Group of the Electronic Parts Engineering Office. He is a member of the Single Event Effects test team. He has participated in many single event effects tests at off-site radiation facilities such as Brookhaven National Lab, Texas A&M Cyclotron Facility, the University of California, Davis, Cyclotron Facility and Lawrence Berkeley National Lab. He has been a co-author on several technical papers. Tetsuo received NOVA Award in 1999, for customer focus and alignment. The award was for staying on schedule and for making efforts to reduce costs.

Jeff Patterson received his B.S. in physics and mathematics from the Rose Hulman Institute of Technology in 1991 and a Ph.D. in nuclear physics from the University of Colorado at Boulder in 2001. Thesis work consisted of precision measurements of a pion-spin polarized proton asymmetry. These measurements are an indication of the strange contribution to the nucleon quark sea. He joined the Jet Propulsion Laboratory in 2001 and is a senior member of the Radiation Effects Group of the Electronic Parts Engineering Office. His current research interests include charge collection mechanisms and the development of upset rate calculation tools.

Jonathan Perret received his B.S. in electrical engineering from the California Polytechnic University, Pomona, in 1980 and M.S. in electrical engineering from California State University, Los Angeles. He joined the Jet Propulsion Laboratory in 1980 and is a principal engineer on section staff in the Electronic Parts Engineering Office. He has developed and delivered avionics hardware at JPL for the Galileo, Mars Observer, Cassini, Mars Pathfinder and Deep Space 2 spacecraft. Currently, he is working to improve the development, verification and space qualification processes for microelectronic devices.

David Peters received his bachelor degree from San Jose State University in 1970. In 1971 he was program manager of the Minuteman III Program, and later the MX Program in Silicon Valley until 1987; he worked with the USAF/RADC/NASA team to set up the first Class S microcircuit flow (for spaceflight), and USAF Operating Stock. He was a member of the USAF SPWG Executive Committee (1985-92), qualified National Semiconductor, and later, Philips/Signetics to the JAN Class S Microcircuit Standardization Program. From 1987 to 1995, he worked as EEE parts manager and principal engineer of the NASA Space Station Freedom Program Office (Level II). He also served as chairman of the Space Station EEE Parts Control Board and Radiation Test Splinter Group for over three years. He joined the Jet Propulsion Laboratory in 1997 and is a senior engineer in the Project Support Group of the Electronic Parts Engineering Office. He has supported SeaWinds programs 1a and QuikSCAT, the Space Transponding Modem (STM) Project, GRACE and GALEX Projects. He is currently supporting the NEPAG Project as active eevice lead engineer. He has received numerous NASA Technical Merit Awards.

Mihail Petkov received his B.S. (1987) and M.S. in physics and engineering physics (1989) from the University of Sofia, Bulgaria, and Ph.D. in physics from Washington State University (1998). He did his graduate work in positron annihilation spectroscopy at Brookhaven National Laboratory and Washington State University (WSU). He joined the Jet Propulsion Laboratory in 1991 and is a senior member of the Failure Analysis Group of the Electronic Parts Engineering Office. He has published 30 refereed papers on electronic and vacancy-like defects in semiconductor materials, layered structures, and interfaces of electronic devices. He and other collaborators from IBM and WSU pioneered the development of positron annihilation spectroscopy as a characterization tool for porous low-k dielectrics, which yields critical microstructural information for the low-k integration in device fabrication. He has a broad range of interests in novel semiconductor materials and technologies, with emphasis on low-k (interlevel) and high-k (capacitor and gate) dielectrics in integrated circuits, Si nanocrystal non-volatile memory technology, SOI, Si-Ge, the effects of extreme thermal and radiation space environments on materials and devices.

Bruce Pritchard received a B.S in electrical engineering from UCLA in 1970, an M.S. in electrical engineering from the University of Maryland at College Park in 1976, and an M.B.A. from the University of Phoenix in 1992. Bruce has over 30 years of radiation experience. He joined the Jet Propulsion Laboratory in 2001 and was previously with Litton Guidance and Control Systems for 17-1/2 years, Delco Electronics for 7- 1/2 years, and Harry Diamond Laboratories for 5 years. He has worked on radiation effects at the part, circuit/module, and system level, including specifications, system survivability design, radiation analysis and testing of parts, circuits, instruments, and systems, plus hardness assurance. While his earlier work concentrated on hardened military systems, more recent work (prior to JPL) was on satellite systems and other spacecraft. In 2002 the first paper he submitted to the IEEE NSREC Data Workshop ("Radiation Effects Predicted, Observed, and Compared for Spacecraft Systems") was selected as co-winner of the best Data Workshop paper.

Ed Powell is a senior component specialist with the Parts Engineering Group. He transferred to group in 1982 after 15 years of experience in JPL quality assurance. Areas of part specialist responsibilities are discrete semiconductors and crystals, optoelectronics, magnetic devices, electromagnetic and solid-state relays, and passive devices including resistors, capacitors, fuses, thermistors.

Ramin Roosta received his B.S. in electronics engineering from the University of Tehran, M.Sc. and Ph.D. degrees from the University of Southern California in electrical and computer engineering. He joined the Jet Propulsion Laboratory in 2001 and is a senior member of the Parts Engineering Group of the Electronic Parts Engineering Office. He has published more than 30 refereed papers, including a chapter of a text and several manuscripts. His areas of expertise include FPGA/ASIC design, testability and top-down design methodology using VHDL. He has been the principal investigator on several research grants from local and national industry. He is also the recipient of several awards including the San Fernando Valley Engineering Council, Outstanding Engineer Merit Award, Distinguished Engineering Educator Award, IEEE Distinguished Service Award and IEEE Millennium Award. He is currently serving as FPGA/ASIC specialist in the Parts Engineering Group. His area of research includes FPGA and ASIC testability and reliability. Ramin has been serving as the chair of IEEE San Fernando Valley section since 1999.

Deanna (Di Di) Rowe received certification from Glendale Junior College as a CPS (Certified Professional Secretary). She originally worked at the Jet Propulsion Laboratory from 1966 to 1972. From 1972 to 1976 she worked for the director of the Golden State Christian Home for Children. She returned to JPL in 1977. During her 31 years at JPL, Di Di has held several secretarial positions, some of which are data coordinator, group secretary, section support secretary / administrative secretary, division support secretary / senior administrative secretary, Space Relay Experiment (SRE) pre-project secretary, Autonomous Redundancy and Maintenance Management Subsystem (ARMMS) project secretary, Pathfinder project support secretary, Interactions Measurements Payload for Shuttle (IMPS) project secretary. She is currently Office 514 secretary. Di Di received a NOVA Award in 1998 and was nominated for the Manned Spaceflight Award in 1989 and 1990.

Ron Ruiz has over 20 years of experience in the field of electron microscopy and element analysis, using energy dispersive spectroscopy (EDS) and other forms of imaging, including infrared. He joined the Jet Propulsion Laboratory in 1982 as an electronics technician in the Electronic Parts Engineering Office while pursuing an A.S. degree at Glendale Community College. His contributions have included a patent in fuel cell materials technology, two NASA tech brief articles -- one titled " Viewing Integrated-Circuit Interconnections by SEM" and the other titled " Sputter Deposition of Catalysts for Fuel-Cell Electrodes." He has also co-authored over fifteen technical papers on barrier materials for semiconductor applications, in support of Dr. Marc Nicolet' s electrical engineering research group at Caltech. Ron has also been a part of tiger teams investigating anomalies with the Galileo data tape recorder; Mars Global Surveyor reaction wheel-squeal; and most recently, hot-spot concerns with the GALEX APE hardware. Ron is a certified Level II infrared thermographer and a member of both the Southern California Society for Microscopy and Microanalysis and the Electronic Device Failure Analysis (EDFAS) Society.

Mike Sandor graduated from the Detroit Institute of Technology with a BSEE, and from the University of Utah with a master' s degree in engineering administration (MEA). He also graduated from United States Air Force Officer Training School and worked as an elec-

tronic projects military officer with the U.S. Air Force, responsible for the reliability, test, and analysis of electronic components and hardware used in Minuteman I & II, Titan II, F-4, and F-15 aircraft weapon systems. Subsequently, he worked as a manager at National Semiconductor Corp., General Electric Corp., and Advanced Micro Devices, responsible for multiple semiconductor products. Responsibilities included product engineering, manufacturing, product development, and product/process reliability. Mike is currently a task manager at the Jet Propulsion Laboratory, responsible for developing and applying commercial off-the-shelf (COTS) insertion methodologies, reliability measurements, proper evaluations, and instituting guidelines when using COTS electronic parts in space flight hardware.

Leif Scheick received his B.S. in physics from Wofford College in 1992 and did his graduate work in radiation physics in semiconductor devices at Clemson University. In 1996, he received an M.S. in physics and in 1999, he received a doctorate in physics focusing on microdosimetric measurement using arrays of floating gates. He joined the Jet Propulsion Laboratory in 1999 and is a senior member of the Radiation Effects Group of the Electronic Parts Engineering Office. He has published several refereed papers, including work on single hard errors in commercial DRAMs and SRAMs used on spacecraft, SEE response in mixed signal devices, and the effect of temperature on radiation response of silicon devices. He has been involved in both SEE (SEU, SEL, SEFI , SEGR) and TID testing of devices for NASA missions. He has provided radiation support for such missions as MER, Cloudsat, Picasso, Calypso, and MRO.

Luis Selva received his B.S. from the University of Southern California in mechanical engineering in 1995 and his M.S. in physics from California State University, Los Angeles (CSLA) in 2001. Currently, he is finishing up a second master' s degree in science from the UCLA School of Medicine in the field of biomedical physics. His plans are to pursue a Ph.D. in physics. While an academic part time student at JPL, Selva's research revolved around the design and implementation of cryogenic and ambient temperature radiation experiments in power MOSFETs, SRAMs, CPUs, LEDs and active pixel sensors. Luis has presented and/or published 15 scientific papers in various research and non-research communities. He is listed in Marquis Who' s Who in America 2002. In 2000 he was awarded the Alumni Certificate of Honor for "outstanding and distinguished academic achievement" from CSLA. In 1999, he was awarded the Eugene Cota Robles scholarship from UCLA. In 1998, he won 1st place at the 12th annual California statewide graduate student research competition for the California State University system with a paper entitled "Ion Induced Electric Field Transient..the Single-Event Gate Rupture (SEGR)." In 1998, he received the "Award for Excellence" and the "Process Improvement Award" from JPL as a team member of the Radiation Test Group and was recognized with the "Graduate Honor Student" from CSLA. In 1997, he was a finalist at the 11th annual California statewide graduate student research competition with a paper entitled "Total Dose response of the ACTEL A1020B."

Patrick Smith joined the Jet Propulsion Laboratory in 2000. Dr. Smith was previously the manager of the materials and chemical analysis laboratory at IBM East Fishkill (NY). The materials and chemical analysis lab was responsible for providing all analytical support to the joint IBM / Infineon semiconductor process development alliance in the Semiconductor Research and Development Center; the lab also provided analytical support to IBM's ceramic packaging development and manufacturing activities at East Fishkill. Dr. Smith was an active member of Sematech's Analytical Lab Managers' Council. Prior to his management positions, he concentrated technically on the characterization of semiconductor devices by transmission electron microscopy.

Jeff Sokol received a B.E.S. from the State University of New York at Stony Brook and an M.S. in electrical engineering from New York University in 1972. In 1980, he finished his Ph.D. in electrical engineering at the Polytechnic Institute of New York. Before coming to the Jet Propulsion Laboratory in 2001, he worked at Corbman Sokol & Associates, Hughes Space & Communications, Teledyne Systems and MTS.

Frank Stott received his B. S. in physics from the University of Chicago in 1961. He has nearly 40 years of experience in electronic parts engineering and reliability engineering. His early work experience was at Autonetics, where he worked on evaluation and testing of diodes for Minuteman and other programs, and as a reliability engineer on the F-111 Avionics program. He has been a JPL employee since 1973, where most of his work has been on digital microcircuits. He has supported every major JPL project, including Viking, Voyager, Galileo, Cassini, Mars Odyssey, Stardust, X-2000, MER and MRO, and served as contract technical manager for Cassini AACS ASICs. For the last 20 years, he has specialized in microprocessors, memories, FPGAs and other large-scale inte-

grated circuits, and has co-authored papers on microprocessor test methodology. He is currently a senior engineer in the Parts Engineering Group

Gary Swift received his B.S. in engineering physics from the University of Oklahoma in 1975 and did his graduate work in nuclear engineering at the University of Illinois at Urbana-Champaign. He joined the Jet Propulsion Laboratory in 1991 and is a senior member of the Radiation Effects Group of the Electronic Parts Engineering Office. He has published more than 20 refereed papers, including work on dielectric rupture in commercial DRAMs and field-programmable gate arrays used on spacecraft. He has a broad range of single event, total dose and dosimetry interests, with particular emphasis on efficient radiation screening of commercial microelectronics for space applications, microdosimeters, mitigation techniques for radiation effects in space, and understanding the physical mechanisms of radiation effects in emerging microelectronics. Gary and other group members received the JPL/NASA Excellence Award in 1998. They also received the Outstanding Paper Award at the 1999 Nuclear and Space Radiation Effects Conference for their paper entitled " Angular and Energy Dependence of Proton Upset in Optocouplers," which explained how direct ionization from protons increases the upset rate in optocouplers.

Jay Sucher is the group supervisor of the Parts Acquisition Group. He is currently attending the University of Phoenix earning his B.S. in business administration. He started to work at JPL in July 2001 as a contractor in the Quality Assurance Section, where he helped develop and write the current set of quality clauses to be used for JPL procurements, and the unified set of quality clauses for NASA centers. He became a JPL employee in February 2002 and moved into management, where he has been a key participant in the design and implementation effort of a laboratory-wide Enterprise Resource Planning System. Prior to joining JPL, his experiences included propulsion products assembly of the Atlas, Delta and space shuttle main engines, then quality assurance and quality assurance management at Rocketdyne, aviation mechanical and flight training leading to aircraft maintenance shop ownership and operations of an FAA Certified Repair Station; and, management and operations of a family-owned business.

Jim Weiler graduated from Loyola Marymount University with a B.S. in nuclear science (emphasis in nuclear physics and electrical engineering), California State University, Long Beach (BSEE with emphasis on filter and oscillator design), California Lutheran University/ Pepperdine University (MBA with emphasis on MIS). He is a member of Eta Kappa Nu. Jim has twenty-three years of experience in RF and microwave components. He was employed at Hughes Aircraft, Micropac, Mills Resistor, Teledyne and TRW prior to joining NASA/JPL in 1998. Jim has made many presentations at the International Microwave Symposium, IMAPS Workshops and IEEE meetings, WESCON and at universities and elementary schools. He has published an IEEE technical paper and several abstracts in the areas of moisture in hybrid microelectronics and hydrogen effects on tantalum nitride resistor chips and GaAs MMICs. Jim is the chair of the IEEE San Fernando Valley Section Microwave Theory and Techniques Society Chapter - 1995 to 2001, member of IEEE and IMAPS.

Mark White received his B.S. in electronics engineering in RF/microwave communications from Metro State College, Denver, CO, in 1986, and his MBA in operations management from the University of Colorado in 1995. He is currently completing his Graduate Professional Certification in Engineering Management (August, 2003) at the University of Colorado, and is pursuing concurrent M.S./Ph.D. degrees in microelectronics and materials reliability engineering at the University of Maryland, Department of Materials and Nuclear Engineering. He joined the Jet Propulsion Laboratory in 2000 and is a senior member of the Parts Engineering Group in the Electronic Parts Engineering Office. Prior to JPL, Mark spent twelve years at Lockheed Martin/Martin Marietta supporting both DOD and NASA projects in components engineering/mission assurance organizations, and was with Telectronics Pacing Systems for two years, in R&D and product development of hybrid-based, implantable pacemakers. His current research interests include reliability focused, microelectronics advanced studies and derating. He is currently contract technical manager for a major hybrid supplier and possesses a broad knowledge of EEE parts, and extensive experience in program parts requirements and management. He has received the NASA Team Award as a member of the 2001 Mars Odyssey Project Team (9/02), the NASA Public Service Group Achievement Award for the Stardust spacecraft flight system design, development, launch and operation (5/00), the Special Recognition Award for significant contributions and technical leadership to multiple NASA programs resulting in cost-effective solutions with minimal program impact (12/99), and the High-Performance Achievement Award for avionics cycle time reduction, significantly reducing the turnaround time from hardware development through final build (5/99).

Candice Yui graduated from California State Polytechnic University in 2001 with a B.S. in electrical engineering. She first worked at the Jet Propulsion Laboratory as an academic part-time student but became a full-time radiation effects engineer in the summer of 2001. She is currently involved in total dose testing with an emphasis in ELDRS (enhanced low-dose rate) and single-event effects testing of Xilinx FPGAs. Candice is also actively involved in the radiation effects community, submitting papers at the annual Nuclear and Space Radiation Effects Conference and other symposiums.

Chris Zuniga received his B.S. and M.S. in electrical engineering from California State University, Fullerton, in 1988 and 2000, respectively. He joined the Jet Propulsion Laboratory as a contract employee in 1999 and is a member of the Parts Engineering Group of the Electronic Parts Engineering Office. He began his career in the commercial sector 13 years ago as a firmware engineer developing code for microcontrollers used in video post-production equipment. He also worked as a component engineer for a manufacturer of UNIX-based computer systems designed for the telecommunications industry. He presently supports parts specialists by performing tasks such as submitting request for quotations for upscreening components at outside laboratories, tracking costs quoted for testing electronic parts, reviewing and risk rating acoustic microimages and X-rays of microcircuits, assisting in the compilation of institutional parts and approved vendor lists.

Section 8

GLOSSARY

Excellence in the selection, evaluation, and acquisition of reliable microelectronics for space applications based on the latest technical knowledge, superior laboratory capabilities, efficient and cost-effective processes, and commitment to customer service.

EPE Vision Statement

2002 Annual Report EPE

Acronyms and Abbreviations

AACS	attitude and articulation control subsystem
AIRS	Atmospheric Infrared Sounder
APE	attitude and articulation control subsystem processing equipment
APL	Approved Parts List
ASIC	application-specific integrated circuit
AWG	automatic wave generator
BJT	bipolar junction transistor
CET	Cost Estimating Tool [software]
CITFET	complementary heterojunction field-effect transistor
CMOS	complementary metal-oxide semiconductor
COTS	commercial off-the-shelf
CSE	camera support electronics
CVD	chemical vapor deposition
DFT	design for test
DPA	destructive physical analysis
DRAM	dynamic random access memory
EBIC	electron-beam-induced conductivity
EDX	energy-dispersive X-ray
ELDRS	enhanced low dose rate sensitivity
EPE	Electronic Parts Engineering [office]
EPINS	Electronic Parts Information Network System [software]
ESD	electrostatic discharge
FPGA	field programmable gate array
FTE	full-time equivalent
FY	fiscal year
GALEX	Galaxy Evolution Explorer
GIDEP	Government- Industry Data Exchange Program
GOMAC	Government Microelectronics Applications Conference
GRACE	Gravity Recovery and Climate Experiment
HEB	hot electron bolometer
IAE	Inflatable Antenna Experiment
IEEE	Institute of Electrical and Electronics Engineers
ILD	interlayer dielectric
IM&O	institutional management and operations
IMAP	Internet Message Access Protocol
IPPR	Institutional Parts Program Requirements
IRPS	International Reliability Physics Symposium
JFET	junction field-effect transistor
JPL	Jet Propulsion Laboratory
LED	light-emitting diode
LET	linear energy transfer
LTMPE	Low-Temperature Microgravity Physics Experiment
MAM	mission assurance manager
MARSIS	Mars Advanced Radar for Subsurface and Ionospheric Sounding

MEMS	microelectromechanical system
MEPSI	Micro-Electromechanical-based Picosat Satellite Inspection
MER	Mars Exploration Rover
MLS	Microwave Limb Sounder
MMIC	monolithic microwave integrated circuit
MMR	monthly management review
MOSFET	metal-oxide field-effect transistor
MRO	Mars Reconnaissance Orbiter
MRS	Materials Research Society
MTTF	mean time to failure
MVP	Multimission VICAR Planner
NAND	AND gate followed by NOT gate
NASA	National Aeronautics and Space Administration
NEPAG	NASA EEE Parts Assurance Group
NEPP	NASA Electronic Parts and Packaging [program]
NMP	New Millennium Program
NOVA	Notable Organizational Value Added [award]
NSPAR	nonstandard parts approval request
NSREC	Nuclear Space Radiation Effects Conference
OSTM	Ocean Surface Topography Mission
PECVD	plasma enhanced chemical vapor deposition
PEM	plastic encapsulated microcircuit
PIE	project interface engineer
PIND	particle impact noise detection
PLA	programmable logic array
PLICETM	programmable antifuse technology
PRB	parts review board
PUG	parts user group
QD	quantum dot
RADECS	Radiation and Its Effects on Components and Systems [professional society]
RF	radio frequency
ROM	rough order of magnitude
RSC	Rockwell Scientific Corporation
SDRAM	synchronous dynamic random access memory
SDST	Small Deep Space Transponder
SEE	single-event effects
SEFI	single-event functional interrupt
SEL	single-event latchup
SEM	scanning electron microscope
SET	single-event transient
SEU	single-event upset
S&MA	Safety and Mission Assurance
SoC	system on a chip
SOI	silicon insulator
SPWG	Space Parts Working Group
SRAM	static random access memory
SRE	Space Relay Experiment
TID	total ionizing dose
TM&O	technical management and operations
TMR	triple modular redundancy
TxRx	transmit- receive
UCLA	University of California, Los Angeles
VICAR	Video Image Communication and Retrieval [software]
WESCON	Western Electronic Show and Convention
X2000	JPL program